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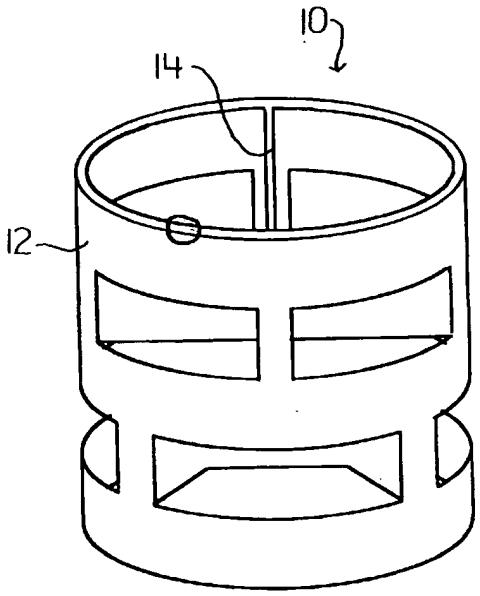
(54) **METHODE ET APPAREIL POUR INOCULER UN BIOFILTRE**

(54) **METHOD AND APPARATUS FOR INOCULATING A BIOFILTER**



(57) Méthode d'inoculation d'un filtre bactérien utilisé dans le traitement des émissions dans l'atmosphère, comportant différentes étapes. Prévoir d'abord une série d'éléments de garnissage rigides convenant à un réacteur à lit fixe. Choisir en second lieu des microorganismes aux caractéristiques souhaitées, puis les immobiliser dans un agent immobilisant qui permet de les garder en vie. Enrober ensuite les éléments de garnissage de l'agent immobilisant pour qu'ils transportent les microorganismes choisis, puis d'un agent de couplage qui permet de garder ces microorganismes en vie. Enfin, distribuer les éléments de garnissage dans toute la cavité intérieure du logement d'un filtre bactérien.

(57) A method for inoculating a biofilter intended for use in treating air emissions. Firstly, providing a plurality of rigid packing elements suitable for use in a packed bed reactor. Secondly, selecting microorganisms with desired characteristics. Thirdly, immobilizing the selected microorganisms in a cell immobilizing agent compatible with the viability of said selected microorganisms. Fourthly, coating the packing elements with the immobilizing agent, such that the packing elements become carriers of the selected microorganisms. Fifthly, coating the packing elements with a cross-linking agent compatible with the viability of the selected microorganisms. Sixthly, distributing the packing elements throughout an interior cavity of a biofilter housing.

ABSTRACT OF THE DISCLOSURE

A method for inoculating a biofilter intended for use in treating air emissions. Firstly, providing a plurality of rigid packing elements suitable for use in a packed bed reactor. Secondly, selecting microorganisms with desired characteristics. Thirdly, immobilizing the selected microorganisms in a cell immobilizing agent compatible with the viability of said selected microorganisms. Fourthly, coating the packing elements with the immobilizing agent, such that the packing elements become carriers of the selected microorganisms. Fifthly, coating the packing elements with a cross-linking agent compatible with the viability of the selected microorganisms. Sixthly, distributing the packing elements throughout an interior cavity of a biofilter housing.

2186202

TITLE OF THE INVENTION:

method and apparatus for inoculating a biofilter

NAME OF INVENTOR:

Richard Nigel Coleman

FIELD OF THE INVENTION

The present invention relates to a method and apparatus for inoculating a biofilter and, in particular, a biofilter used for treating air emissions.

BACKGROUND OF THE INVENTION

One shortcoming of biofiltration is that a period of time is required for selected microorganisms with desired characteristics to become acclimatized and present in sufficient concentrations to perform their intended function. During this period of time, the selected microorganisms must compete for space and nourishment with other microorganisms present in the biofilter. Inoculation of the biofilter has become a recognized manner of accelerating this acclimatization process. With inoculation the initial concentration of the selected microorganisms is increased substantially. Inoculation of the biofilter is discussed in the patent and technical literature, such as United States Patent 4,662,900 by Ottengraf from 1987 and a paper delivered by Dr. Richard N. Coleman to the 12th Annual General Meeting of BIOMINET in November 1995, entitled "Specific Biofilter Process Design Using Bacteria Capable of Removing Hydrogen Sulphide from Air Emissions".

In order to inoculate the biofilter, the selected

microorganisms must first be immobilized in a form that can easily be handled. There are a variety of methods of cell immobilization, as described in texts such as "Immobilized Cells and Organelles" edited by Bo Mattiasson and published by CRC Press, Boca Raton, Florida. The most common of these methods is to immobilize the cells in polymer beads.

At the present time polymer beads are used in the treatment of liquid wastes, but generally not in biofilters used for treating air emissions. The current method of inoculating a biofilter consists of inserting into the biofilter a volume of liquid containing the selected microorganisms into the biofilter. Although this creates an area of concentration within the biofilter, it takes time for a spatial distribution of the selected microorganisms to occur within the biofilter. During this period of time, the selected microorganisms still must compete for space and nourishment with other microorganisms present in the biofilter.

SUMMARY OF THE INVENTION

What is required is a method for inoculating a biofilter that results in an improved spatial distribution of the selected microorganisms.

According to one aspect of the present invention there is provided a method for inoculating a biofilter. Firstly, providing a plurality of rigid packing elements suitable for use in a packed bed reactor. Secondly, selecting microorganisms with desired characteristics. Thirdly, immobilizing the selected microorganisms in a cell immobilizing agent compatible with the viability of said selected microorganisms. Fourthly, coating the packing elements with the immobilizing agent, such that the packing elements become carriers of the selected microorganisms. Fifthly, coating the packing elements with a cross-linking agent compatible with the

viability of the selected microorganisms. Sixthly, spatially distributing the packing elements throughout an interior cavity of a biofilter housing.

According to another aspect of the present invention there is provided a biofilter packing element which includes a rigid three dimensional structure. The structure has a first coating including an immobilizing agent impregnated with selected microorganisms. The structure also has a second coating including a cross-linking agent.

According to a final aspect of the present invention there is provided a biofilter that includes a housing with an interior cavity. Filter medium is disposed in the housing. The filter medium includes a plurality of biofilter packing elements. Each of the packing elements includes a frame-like structure. The structure has a first coating including an immobilizing agent impregnated with selected microorganisms. The structure has a second coating including a cross-linking agent. The packing elements are spatially distributed throughout the interior cavity of the housing. It is preferred that the spatial distribution be random in order to provide a non-linear flow path through the interior cavity of the housing.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other features of the invention will become more apparent from the following description in which reference is made to the appended drawings, wherein:

FIGURE 1 is a perspective view of a biofilter packing element constructed in accordance with the teachings of the present invention.

FIGURE 2 is a top plan view of the biofilter packing element illustrated in **FIGURE 1**.

FIGURE 3 is a magnified cutaway view of the biofilter

packing element illustrated in **FIGURE 1.**

FIGURE 4 is a biofilter constructed in accordance with the teachings of the present invention, using a plurality of the packing elements illustrated in **FIGURE 1.**

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The preferred embodiment, a biofilter packing element generally identified by reference numeral 10, will now be described with reference to **FIGURES 1** through **4.**

Referring to **FIGURE 1,** biofilter packing element 10 includes a rigid three dimensional structure 12. Suitable rigid packing elements 10 are available through a variety of suppliers. The packing elements are selected in a geometric configuration which provides a maximum possible surface area per volume. Beneficial results have been obtained through the use of a biofilter packing element sold by FABCO PLASTICS of Toronto, Ontario under the Trademark PALL rings. Referring to **FIGURE 2,** PALL rings have a cylindrical frame-like structure, that has a plurality of internal cross-members 14. In accordance with the teachings of the present invention, frame-like structure 12 is specially coated. Referring to **FIGURE 3,** frame-like structure 12 has a first coating 16 of an immobilizing agent impregnated with selected microorganisms 17. Immobilizing agents are well known in the technical literature. The particular immobilizing agent selected must be compatible with the viability of the selected microorganisms. In initial testing, the selected microorganism was *Thiobacillus thiooxidans*. Beneficial results were obtained when sodium alginate was used as the immobilizing agent. There are various alternative immobilizing agents which may be tested for viability with selected microorganisms, such as poly-acrylamide. Frame-like structure 12 also has a second coating 18 including a cross-linking agent. The cross-linking agent must also be compatible with the viability and activity of the

selected microorganisms. In initial testing, beneficial results were obtained when aluminum nitrate was used. There are alternative cross-linking agents which may be tested for viability with selected microorganisms, such as calcium chloride. Any agent that is capable of chemically connecting one part of a molecule to an adjacent molecule to provide a cross-link may be used. The cross-linking agent penetrates the immobilizing agent containing the selected microorganisms, providing rigidity to the coating and firmly entrapping the cells within the coating. Referring to **FIGURE 4**, a biofilter 20 is provided which includes a housing 22 with an interior cavity 24, in which is positioned filter medium in the form of a plurality of biofilter packing elements 10.

The method of use of biofilter packing elements 10 will now be described with reference to **FIGURES 1** and **2**. The method includes the following steps. Firstly, providing a plurality of untreated biofilter packing elements. Secondly, selecting microorganisms with desired characteristics. Cells for the selected microorganisms are grown in a liquid culture. The cells are then concentrated by centrifuging. Beneficial results have been obtained by centrifuging at 10,000 x G for 15 minutes. Thirdly, immobilizing the selected microorganisms in a cell immobilizing agent compatible with the viability of said selected microorganisms. The cells recovered by centrifuging are re-suspended in the immobilizing agent. In this case the immobilizing agent consisted of distilled water mixed with sodium alginate to form a 2% sodium alginate solution. The re-suspended cells in the immobilization agent should be only 10% of their original volume. Care must be taken in mixing the sodium alginate. It is preferable to divide the quantity of distilled water in half. The selected microorganisms are re-suspended in one half. Sodium alginate is slowly added to the other half. The sodium alginate is slightly hydrophobic. It will not mix well in water at first. Care should be taken to add the sodium alginate as finely as possible to avoid the formation of large clumps. Large clumps

are difficult to hydrate. When all the sodium alginate has been added and is uniformly hydrated, the half containing the re-suspended selected microorganisms is added, and the two halves are mixed together. Fourthly, coating the packing elements with the immobilizing agent, such that the packing elements become carriers of the selected microorganisms. In preparation for coating the PALL rings are treated in a 50% dichromic acid glass cleaning solution for 24 hours. The dichromic acid prepares them for use by producing a rough surface so the coating will adhere better. At the end of the treatment period the PALL rings are washed with distilled water to remove all traces of dichromic acid. The PALL rings are then dipped into the microorganism containing immobilizing agent for a few seconds, and then removed. Fifthly, coating the packing elements with a cross-linking agent. The PALL rings are placed into a bath of cross-linking agent, where they are left undisturbed for one hour. In initial testing 0.1M aluminum nitrate was used. Sixthly, spatially distributing biofilter packing elements 10 throughout interior cavity 24 of housing 22 of biofilter 20. Referring to **FIGURE** 4, biofilter 20 is filled with biofilter elements 10. Biofilter packing elements 10 are, preferably, randomly arranged in order to provide a non-linear flow through interior cavity of housing 22. The coatings of biofilter packing elements 10 must not dry at any time. To prevent drying, water saturated air is circulated through interior cavity 24 of housing 22 of biofilter 20. During operation of biofilter 20, it is continuously supplied with a water vapour saturated gas stream and nutrients appropriate for the selected microorganisms. Care is taken during all steps to ensure that temperature of the microorganisms is controlled so as not to adversely effect their viability with excess heat.

The concentration of cells in the coatings on biofilter packing elements 10 is in excess of 1×10^8 per dry gram of coating. When the teachings of the present method as followed, there is an initial concentration that can reach its optimum

operating capacity within days. It is preferred that the filter medium consist solely of biofilter packing elements 10. This means that no peat moss, compost, soil, bark, etc of any kind is to be added to the filter medium. In order for packing elements 10 to work by themselves they must be rigid, so that they can support each other. When this teaching is followed there are no resident microorganisms with which the selected microorganisms must compete for space and nourishment.

When the teachings of the present method were employed in initial testing with volatile air emissions, it was determined that the initial high and specific microbial loading minimized the time for acclimation of the biofilter and allowed the biofilter to quickly move to optimum operating capacity. The process optimizes the occupation of available sites by selected microorganisms. It minimizes the volume of the reactor. The spatial arrangement allows maximum contact of the microorganisms with volatile air emissions.

It will be apparent to one skilled in the art that modifications may be made to the illustrated embodiment without departing from the spirit and scope of the invention as hereinafter defined in the Claims.

THE EMBODIMENTS OF THE INVENTION IN WHICH AN EXCLUSIVE PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS FOLLOWS:

1. A method for inoculating a biofilter, comprising the steps of:

firstly, providing a plurality of rigid packing elements suitable for use in a packed bed reactor;

secondly, selecting microorganisms with desired characteristics;

thirdly, immobilizing the selected microorganisms in a cell immobilizing agent compatible with the viability of said selected microorganisms;

fourthly, coating the packing elements with the immobilizing agent containing the selected microorganisms, such that the packing elements become carriers of the selected microorganisms;

fifthly, coating the packing elements with a cross-linking agent compatible with the viability of said selected microorganisms; and

sixthly, distributing the packing elements throughout an interior cavity of a biofilter housing.

2. The method as defined in Claim 1, wherein the immobilizing agent is sodium alginate.

3. The method as defined in Claim 1, wherein the immobilizing agent is poly-acrylamide

4. The method as defined in Claim 1, wherein the cross-linking agent is aluminum nitrate.

5. The method as defined in Claim 1, wherein the cross-linking agent is calcium chloride

6. A method for inoculating a biofilter, comprising the steps of:

firstly, providing a plurality of rigid packing elements suitable for use in a packed bed reactor, the rigid packing elements having a geometric configuration which provides a maximum possible surface area per volume;

secondly, roughening the surface of the packing elements;

thirdly, selecting microorganisms with desired characteristics;

thirdly, immobilizing the selected microorganisms in a cell immobilizing agent compatible with the viability of said selected microorganisms;

fourthly, coating the packing elements with the immobilizing agent containing the selected microorganisms, such that the packing elements become carriers of the selected microorganisms;

fifthly, coating the packing elements with a cross-linking agent compatible with the viability of said selected microorganisms; and

sixthly, distributing the packing elements randomly in an interior cavity of a biofilter housing such that a non-linear flow through the biofilter housing is achieved.

7. A biofilter packing element, comprising:

a rigid three dimensional structure having a coating impregnated with selected microorganisms.

8. The biofilter packing element as defined in Claim 7, wherein the three dimensional structure is a frame-like structure.

9. The biofilter packing element as defined in Claim 8, wherein the frame-like structure is a cylinder with a plurality of internal cross-members.

10. A biofilter packing element, comprising:

a cylindrical frame-like structure having a plurality of internal cross-members, the structure having a coating impregnated with selected microorganisms.

11. A biofilter, comprising:

a housing with an interior cavity;

filter medium disposed in the housing, the filter medium including a plurality of biofilter packing elements, each of which includes:

a rigid frame-like structure having a coating impregnated with selected microorganisms.

the packing elements being distributed throughout the interior cavity of a housing.

12. The biofilter as defined in Claim 11, wherein the filter medium consists solely of said biofilter packing elements distributed randomly throughout the interior cavity of the housing, thereby providing a non-linear flow pattern through the housing.

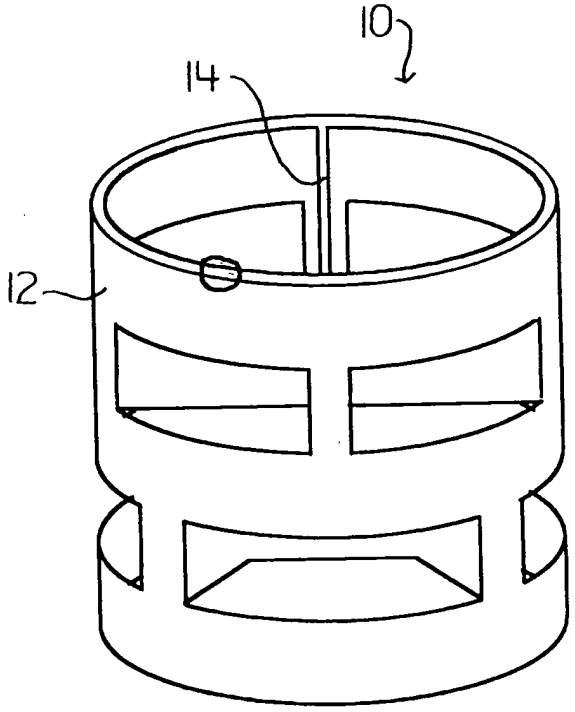


FIGURE 1

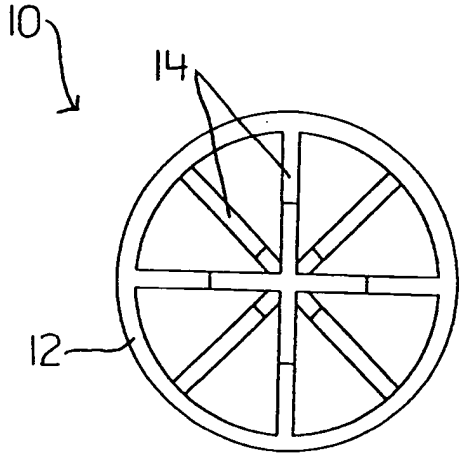


FIGURE 2

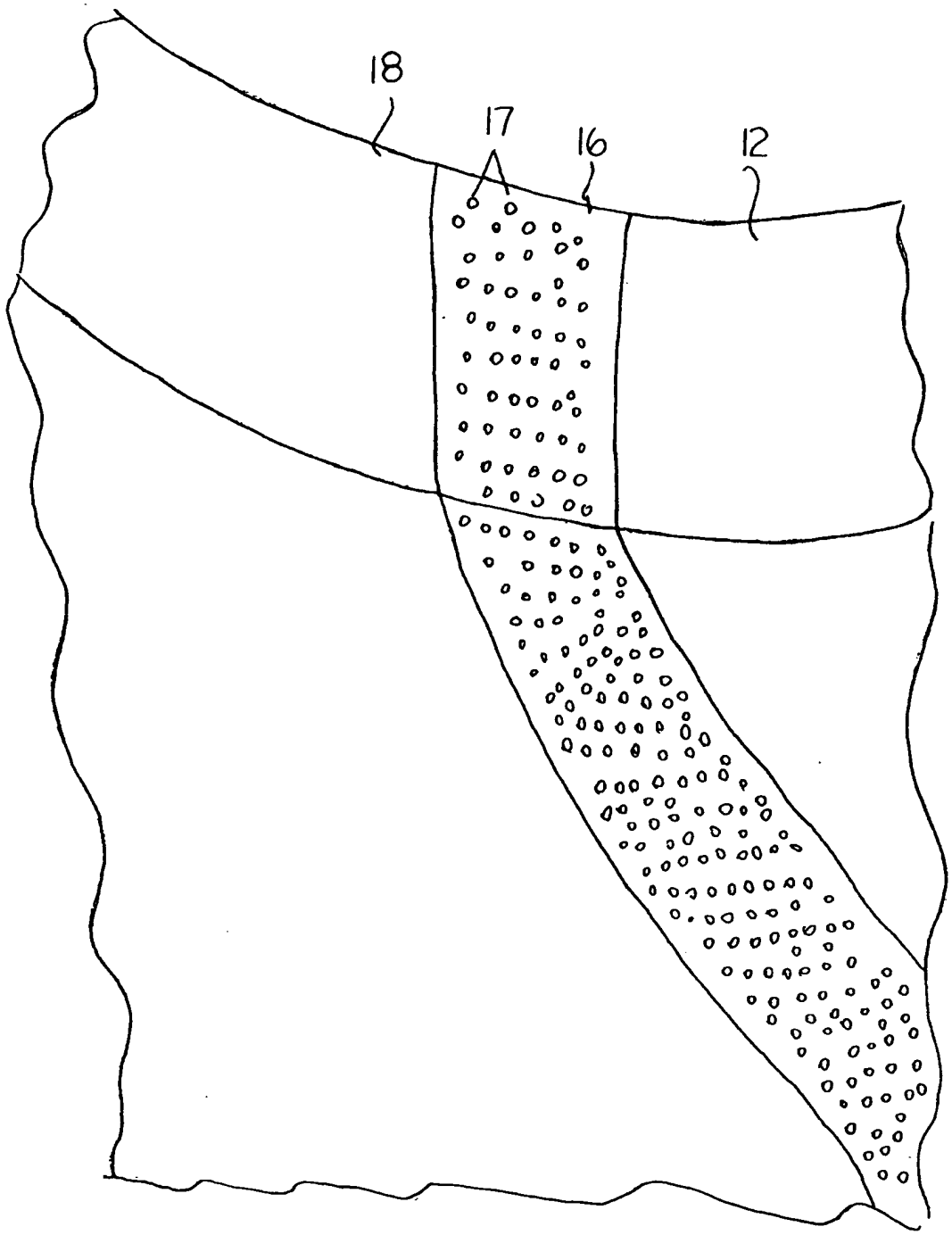


FIGURE 3

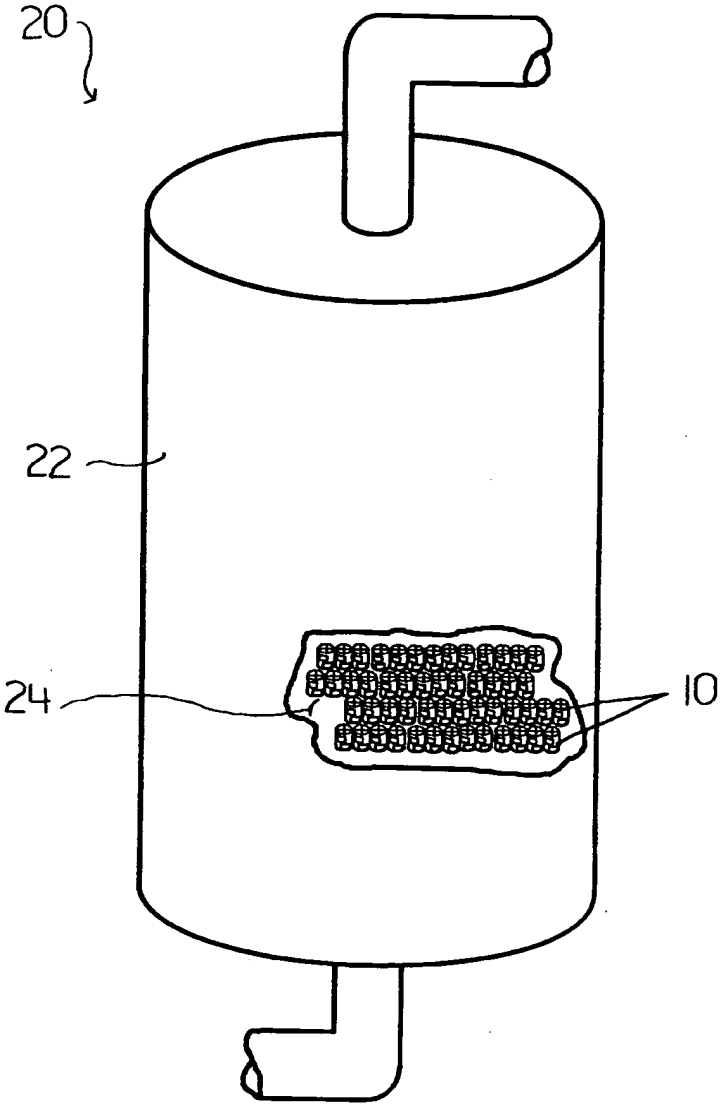


FIGURE 4